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(54) Title: POLYMERIC COMPOSITION HAVING ENHANCED SURFACE ENERGY AND METHOD FOR OBTAIN- ING SAME (57) Abstract A polymeric composition having enhanced surface energy and a method for obtaining the same, such method comprising blending from about 99.5 % to about 90.0 % by weight of the polymeric material with from about 0.5 % to about 10.0 % by weight of an amphiphile having the formula: $RA(CHR^2[CH_2]_nA^1)_mR^1$ where R and R ¹ are selected from the group consisting of the alkyl, aryl, alkylaryl, acyl and arylacyl derivatives of an aliphatic or aliphatic/aromatic mono-acid with a molecular weight of from about 200 to about 500 daltons, A and A ¹ are polar atoms or groups, R ² is selected from the group consisting of H, CH ₃ and C ₂ H ₅ , n is from 0 to 3 and m is from 2 to 20. A and A ¹ are selected from the group consisting of O, S, -NR ³ - and carboxyl, with R ³ selected from the group consisting of H, CH ₃ and C ₂ H ₅ . An adhesive tape prepared from the product of the method is also disclosed.		

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POLYMERIC COMPOSITION HAVING ENHANCED
SURFACE ENERGY AND METHOD FOR OBTAINING SAME

The present invention relates to low or medium density organic polymeric materials, particularly polyolefins, having enhanced surface energy and to methods for obtaining the same.

5 Low density polyethylene (LDPE) and other low and medium density polyolefins such as polypropylene, alpha-olefin modified polypropylene, polystyrene, TPX, i.e. poly(4-methylpentene-1), and other organic polymeric materials are used in high volume applications in the packaging
10 industry in the form of injection molded parts, free extruded films and extrusion coatings on substrates such as paper, metal foils or non-woven fabrics. As such, it is often desirable to print or coat an exterior polymeric surface to enhance visual appeal, list ingredients, adver-
15 tise, or protect the surface. There is also interest in using films of low and medium density polyolefins with acrylic based or other water-borne adhesives to produce adhesive tapes.

Because of the inherent low surface energy of
20 these polymeric materials, the surface must be modified, that is made more polar, in order to accept most printing ink and coating or adhesive formulations. The current industry practice for surface modification of these materials is to oxidize the surface through flame or corona dis-
25 charge treatment. Either of these treatments produces an acceptable surface, raising the surface energy from about 28 to about 42 dynes/cm². However, the effect is transient and surfaces that reside too long between treatment and printing or coating (i.e., greater than about four weeks)
30 must be retreated for successful application.

In general, adhesive tapes of current technology employ MYLAR^R or other polyesters of high surface energy, rather than polyolefins, as film substrates for water-borne adhesives. Although these films are adequate for present

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uses, there exists a need for films with the strengths and costs of polyolefins combined with the high surface energies of polyesters.

It is, therefore, an object of the present invention to provide a polymeric composition having enhanced surface energy.

It is another object of the present invention to provide low and medium density organic polymeric materials with increased surface energies which are stable for extended time periods.

It is another object of the present invention to provide a method for producing a polymeric material having enhanced surface energy.

It is another object of the present invention to provide a composition for increasing the surface energy of low and medium density organic polymeric materials.

It is another object of the invention to provide high surface energy materials which are suitable for use as adhesive tape substrates.

The present invention provides a method for enhancing the surface energy of a surface of a low or medium density, low surface energy organic polymeric material. The method comprises blending from about 99.5% to about 90.0% by weight of the polymeric material with from about 0.5% to about 10.0% by weight of an amphiphile having the formula



where R and R¹ are selected from the group consisting of the alkyl, aryl, alkylaryl, acyl and arylacyl derivatives of an aliphatic or aliphatic/aromatic mono-acid with a molecular weight of from about 150 to about 500 daltons, R² is selected from the group consisting of H, CH₃ and C₂H₅, A and A¹ are polar atoms or groups, m is from 2 to 20 and n is from 0 to 3. Examples of polar atoms or groups that are useful as A and A¹ include, but are not restricted to, O, S, -NR³- or carboxyls. When A or A¹ is -NR³-, R³ is selected from the group consisting of H, CH₃ and C₂H₅. The value of n may be, but it is not necessarily, the same throughout the

amphiphile. In preferred methods, the blending of the polymeric material with the amphiphile is accomplished by either melt blending, the blending of two solutions containing the polymer and the amphiphile, blending in a high shear mixer or adding the amphiphile as a solid or liquid to the polymeric material during extrusion. Alternatively, the amphiphile could be added to the polymer during work-up immediately after polymerization.

Examples of alkyl, aryl, alkylaryl, acyl and arylacyl derivatives of an aliphatic or aliphatic/aromatic mono-acid with molecular weights of from about 150 to about 500 daltons include, but are not restricted to, alkylbenzenes, aliphatic alcohols, acyl derivatives of saturated fatty acids having carbon atom chain lengths of from about 10 to 26 atoms, soya and tall oil fatty acids, alkylbenzoic acids and tall oil, wood and gum rosin acids.

The present invention also provides for a low or medium density polyolefinic composition with a high surface energy. The high surface energy does not decrease over a period of months. This is in contrast to corona discharge, as normally carried out, which produces a metastable oxidized high energy surface. After about 3 to 4 weeks the surface reverts to a lower surface energy. Consequently, printing and adhesive qualities rapidly deteriorate on storage. The composition is comprised of from about 99.5% to about 90.0% of a low or medium density, low surface energy polyolefin and from about 0.5% to about 10.0% by weight of the amphiphile described above. In a preferred composition $R=R^1$, R^2 is hydrogen, $A = A^1 =$ oxygen, m is 9 and $n = 1$ and the composition is comprised of about 98% of the polyolefin and about 2% of the amphiphile. In another preferred composition $R = R^1$, R^2 is hydrogen, $A = A^1 = -NR^3-$, R^3 is hydrogen, m is 14, and $n = 1$ and the composition is comprised of about 98% of the polyolefin and about 2% of the amphiphile. In yet another preferred composition, $R = R^1$, R^2 is hydrogen, $A = A^1 =$ carboxyl, m is 7, $n = 5$ and the composition is comprised of about 98% of the polyolefin and

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about 2% of the amphiphile.

The present invention also provides for a composition for increasing the surface energy of a low or medium density, low surface energy organic polymeric material whereby the composition is added to the polymeric material. The composition has the formula:



where the composition is the amphiphile described previously.

The present invention also provides for an adhesive tape comprising a low or medium density polyolefinic composition comprising from about 99.5% to about 90.0% by weight of a low or medium density, low surface energy polyolefin and from about 0.5% to about 10.0% of an amphiphile as previously described, and a water-dispersed adhesive. By use of the word "tape" is meant strips, film, sheets and other similar geometries.

When the present invention is used to produce adhesive tapes, the adhesive can be any water-based solution or dispersion. For example, acrylic adhesives work quite well. Best results are achieved with adhesives that can act as hydrogen donors for hydrogen bonding.

The amphiphile disclosed in the present invention has a central hydrophilic component and two lipophilic components (represented by R and R¹ in the above formula) attached to either end of the central component. Without being bound by the theory, it is believed that the two lipophilic regions are most compatible with the organic polymeric material. Therefore, it is thought that the amphiphile is anchored in the polymeric material by those lipophilic portions. The hydrophilic portion comprising alternating organic and polar groups, in the middle of the amphiphile, is less compatible with the organic polymeric material. Therefore, it is thought that the hydrophilic segment resides at the surface of the polymeric material. It is believed that this hydrophilic segment raises the surface energy of the polymeric material. Since the lipo-

philic segment of the amphiphile is anchored in the polymeric material, the surface energy of the polymeric material is increased on a more permanent basis than is possible using previous techniques.

5 The presence of a nitrogen in the central component provides an additional advantage over other polar components. The resulting amphiphile acts as an active hydrogen donor in addition to accepting hydrogen bonding. Therefore, it is possible to tailor the amphiphile for a
10 specific use requiring hydrogen donation from a particular surface coating.

 The amphiphile is generally formed by the reaction of, for example, polyglycols, polysulfides, polyimines or polyester diols with hydrophobes such as fatty acids, rosin
15 acids, alkylphenols or aryl or aliphatic alcohols. The chain length of the hydrophilic segment, polyethylene glycol for example, varies from 2-20 units (where a unit is composed of 1, 2, 3 or 4 carbon atoms and one polar atom or group, for example, one oxygen, sulfur or nitrogen atom or
20 carboxyl group) with a preferred length of about 10 units. The hydrophobes generally have chain lengths of from about 10 to about 26 atoms. The aromatic, aliphatic or mixed alcohols have molecular weights from about 150 to about 500 daltons.

25 There is a preferable limitation to the length of the hydrophilic portion of the amphiphile. At lengths of 2 units the addition of the amphiphile to the polymeric material does not significantly increase the surface energy of the material. At chain lengths of above 20 units, al-
30 though there may be initial improvement in surface energy, the amphiphile leaches easily into aqueous liquids. This results in an eventual lowering of the surface energy of the polymeric material and consequently a loss in printability or suitability as a substrate for adhesive tape. In
35 general, the optimum chain length is 10 units, although specific product usage may require greater or lesser chain lengths.

The increase in surface energy of the polymeric material is measured by the contact angle of water on the surface of the polymeric material. This contact angle is related to printability and suitability as a substrate for adhesive tape. Surface energy is also related to surface polarity and wettability and is extremely difficult to measure directly. Consequently, surface energy is normally measured indirectly by using liquids of known surface energy. When a match occurs, the liquid spreads rapidly over the surface. The surface energy of the surface is then equal to the surface energy of the liquid. More simply, the contact angle of a single substance, for example water, can be measured and the surface energy estimated. Generally, a required contact angle can be determined for the property desired. In the case of printing with normal inks, the water contact angle should be between about 60° to about 70°. In the case of acrylic based adhesives (applied as an aqueous dispersion), the water contact angle should be between about 50° and about 70°. Untreated low density polyethylene, for example, shows a contact angle of 91°. The addition of between 0.5 and 10.0% of the amphiphile to the polymeric material results in contact angles between 70° and 30°.

In addition, it is preferable that the amphiphile concentration not exceed 10% by weight. At amphiphile addition amounts of greater than 10% there is an indication of significant phase separation between the amphiphile and the polymeric material. Once phase separation occurs, there is no improvement in printability or adhesion and little change in the surface energy.

The organic polymeric material is not restricted to low density polyethylene. Other low and medium density polyolefins such as polypropylene, alpha-olefin modified polyethylene and polypropylene, polystyrene, and TPX are also suitable for treatment with the amphiphile for raising their surface energies. These other polyolefins are blended with the amphiphile in like manner as polyethylene.

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In order to provide a more complete understanding of the invention, the following examples are offered by way of illustration and not by way of limitation.

EXAMPLE I

5 A series of amphiphiles were prepared by the esterification of carboxylic acids. These materials were prepared by reacting a polyethylene glycol of the indicated molecular weight with a slight excess over two equivalent weights of the chosen acids under the indicated conditions
10 shown in Table I. The amphiphiles were produced in a reactor arranged for nitrogen blanketing and stirring with an exit condenser to condense removed water. An acidic catalyst was employed for convenience. Table I summarizes reaction conditions and the amphiphiles produced.

15

TABLE I
SYNTHESIS OF AMPHIPHILE A-I

CARBOXYLIC ACID		PEG ⁸		CATALYST		CONDITIONS		REACTION			AMPHIPHILE PRODUCED	
								#	Acid No.	Gardner	Yield % ¹¹	State
Type	Wt. g.	Mol.	Wt. g.	Type	Wt. g.	Hours	T. C					
TORA ¹	520	150	112	H ₃ PO ₄	0.4	29	280	A	11	7	89	Viscous
TORA ¹	520	165	150	H ₃ PO ₂	0.6	32	260	B	12	6	92	Viscous
												Liquid
TORA ¹	520	400	300	H ₃ PO ₂	0.6	29	260	C	11	7	94	Viscous
												Liquid
WOOD ²	543	400	300	H ₂ SO ₄	0.2	39	270	D	11	8	88	Viscous
ROSIN												Liquid
GUM ³	506	400	300	H ₃ PO ₂	0.6	25	270	E	12	6	93	Viscous
ROSIN												Liquid
DIST. ⁴	482	400	300	H ₃ PO ₂	0.6	28	270	F	3	4	90	Viscous
TORA												Liquid
STEARIC ⁵	350	400	249	PTSA ⁹	0.5	20	220	G	4	2 ¹⁰	98	Waxy
												Solid
PALMITIC ⁶	406	400	300	H ₃ PO ₂	0.6	22	220	H	6	2 ¹⁰	98	Waxy
												Solid
TOFA ⁷	208	400	249	H ₃ PO ₄	0.3	22	220	I	12	2	98	Liquid

TABLE I (continued)
NOTES FOR TABLE I

- | | |
|-----|--|
| 1. | Acintol R Types S Tall Oil Rosin, Arizona Chemical Company |
| 2. | W W Wood Rosin, Hercules |
| 3. | Gum Rosin, Brazil |
| 4. | Beviros 95 Distilled Tall Oil Rosin, Arizona Chemical Company |
| 5. | Aldrich Chemical Co., 95% Pure |
| 6. | Aldrich Chemical Co., 99% Pure |
| 7. | Acintol EPG Tall Oil Fatty Acid, Arizona Chemical Company |
| 8. | Linear Polyethylene Glycols of Carbowax Type Produced
by Union Carbide at Various Molecular Weights |
| 9. | Para-toluene sulfonic acid |
| 10. | Molten Color |
| 11. | As % of Theory |

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EXAMPLE II

A glass reactor, fitted with a condenser to collect condensate, a stirrer and arranged for nitrogen blanketing, was charged with 200 parts of branched 18 carbon fatty acids (SylfatTM, Arizona Chemical Co., D-1 fatty acid, acid number 178), 100g of polyethylene glycol (average molecular weight of 400, an average of 9.1 moles of ethylene oxide per chain) and 0.5g of phosphorus acid. The reactor was blanketed with nitrogen, stirred, and the temperature raised to 200°C and held at that temperature for seven hours. After completion of the reaction, the mixture was stripped under vacuum to remove the excess unreacted fatty acid. The resulting amphiphile, J, was produced in 82.5% yield, with a Gardner color of 5 and an acid number of 6.3. This amphiphile was a mobile liquid at room temperature.

EXAMPLE III

The general procedure of Example II was followed to produce amphiphile K. In this case, 40g of nonylphenol ethylene oxide condensate (Igepal 710, GAF Corp., 10-11 mole of ethylene oxide condensate) was reacted with 21g of tall oil rosin (AN 175) for 29 hours in the presence of 21mg of hypophosphorus acid catalyst at 270°C. After completion of the reaction, the amphiphile K was analyzed by gel phase chromatography which indicated a purity of 89% with the major impurity excess rosin (about 10%). The amphiphile K was a viscous oil at room temperature with a Gardner color of 4 and an acid number of 15.

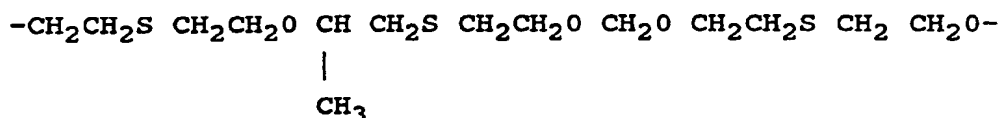
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EXAMPLE IV

Amphiphile L was prepared as follows in a glass reactor fitted with stirrer, heater, nitrogen blanketing, and an exit condenser. Twenty grams of polyethylene glycol (molecular weight of 400) 18.6g of methyl decanoate and 0.2g of para-toluene sulfonic acid were charged to the reactor. The mixture was stirred and heated to 130°C for 1 hour and then 160°C for 1 1/2 hours. The resulting amphiphile was analyzed by gel phase chromatography and determined to be about 98% pure in 100% yield. The amphiphile L had a Gardner color of 3, an acid number of 2 and was a mobile liquid at room temperature.

EXAMPLE V

A 251g sample of Permapol® P-3 Polyol (Thiokol), a mixed hydroxyl terminated oxygen-sulfur ether having a typical structure of



and a molecular weight of 500, was reacted with 350g of tall oil rosin acid in the presence of 0.6g of 50% aqueous hypophosphous acid and was heated at 270°C for four hours. The product, amphiphile M, was obtained in essentially quantitative yield as a viscous amber oil with an acid number of 12.4.

EXAMPLE VI

A sodium dispersion was prepared in a Morton flask with 9.2 g of sodium dispersed in 250 ml of distilled tetrahydrofuran and mixed at 20°C. With continued stirring, a mixture of 22.5 g of polyethylene glycol 400 and 30.1 g of 1-bromohexadecane was added to the reaction mixture and the mixture was raised to reflux. After 48 hours, the sodium was removed by filtration and the tetrahydrofuran was evaporated from the reaction mixture. The crude amphiphile, bis-hexadecyl polyethylene glycol ether, was dissolved in ethyl ether. The ether solution was washed with water and then purified on a silica gel column to produce the purified

amphiphile N. Amphiphile N was obtained as a viscous, pale yellow oil.

EXAMPLE VII

Preparation of a high surface energy polyolefin.

5 An organic polymeric composition with a high surface energy was prepared as follows. A low density polyethylene (Alathon®, with 0.92-0.94 specific gravity, characterized by a melt index of 3.5-4.5 condition E ASTM Standard, produced by the DuPont Company; Tenite® 1924, with
10 0.92-0.94 specific gravity, characterized by a melt index of 3.5-4.5 condition E ASTM Standard, produced by Eastman Kodak; or Dow Resin 5004, with 0.92-0.94 specific gravity, characterized by a melt index of 3.5-4.5 condition E ASTM Standard, produced by Dow Chemical Company) and the selected
15 amphiphiles at various levels were combined together in melt form, by mixing in an extruder or by mixing in a high shear mixer. The means of compounding was not important so long as intimate mixing was accomplished. After compounding, the polymeric product was extruded as a film or was extruded
20 as a film directly onto glass. The surface energy of the film was measured by determination of the contact angle. Table II details polymeric composition produced and the contact angles determined.

 Amphiphile C was also master batched in an extruder.
25 er. Polyethylene resin and the amphiphile were combined in an extruder and then extruded. The extrudate was chopped to make normal resin pellets. The master batch was then extruded onto metal, paper and as a free film. Contact angles determined on those substrates confirm the contact angles
30 shown in Table II. These substrates have also been successfully printed in a plant trial seven weeks after a coated board was produced.

TABLE II
WATER^a CONTACT ANGLES OF LDPE COMPOSITIONS

AMPHIPHILE 2% LEVEL	LDPE	WATER CONTACT ANGLE (b)		
		2% BY WEIGHT	5% BY WEIGHT	10% BY WEIGHT
None	Tenite 1924	91	--	--
A	Tenite 1924	--	--	75
B	Tenite 1924	--	82	75
C	Tenite 1924	71	57	--
D	Alathon 1640	--	58	--
E	Alathon 1640	--	56	--
F	Alathon 1640	65	63	--
G	Tenite 1924	49	57	--
H	Alathon 1640	30	36	--
I	Tenite 1924	31	25	--
J	Alathon 1640	63	16	--
K	Alathon 1640	62	53	--
L	Alathon 1640	74	60	--
M	Alathon 1640	69	70	--
N	Alathon 1640	81	63	--

TABLE II, continued

- (a) Distilled water with 0.01% by weight aniline blue added for contrast
- (b) Decreasing contact angle equals increased surface energy.

EXAMPLE VIII

Amphiphile C from Example I was composited with the polyolefin Alathon 1640 (DuPont) at 1, 2 and 5 weight percent as in Example VII. Water contact angles were determined and the results are listed in Table III. As may be seen in Table III, measurement of the contact angle is less reproducible as the concentration of the amphiphile is increased. This we speculate is related to the limited solubility of the amphiphile in the polyolefin.

TABLE III

10

Weight Percent of Amphiphile	Water Contact Angle
1	81 ± 4
2	71 ± 12
5	57 ± 12

15

EXAMPLE IXSynthesis of an Amphiphilic Amide:

Tall oil rosin was first converted to the rosin acid chloride which was reacted with the polyimine in a pyridine solution. The reaction mixture was maintained at between 0°C to 2°C for 2 hours and then slowly warmed to room temperature over 1 hour. The mixture was held at room temperature for 30 minutes. The product was coagulated by pouring the reaction mixture into a large excess of hexanes. The coagulated product was washed with hexane and redissolved in methanol. The methanol solution was transferred to another vessel and the methanol was removed by evaporation. Table IV details the amphiphiles produced.

TABLE IV

SYNTHESIS OF AMPHIPHILE O

<u>Carboxylic Acid</u>			<u>Polyimine Diamine</u>			<u>Amphiphile</u>	
						Gardner	
5	Type ^a	Wt(g)	Mol. Wt.	Type ^b	Wt(g)	Mol. Wt.	# Color Yield
	TORA	25	302	PEI	24.7	600	0 >18 70% ^c
	(a) TORA = tall oil resin acid;						
	(b) PEI = polyethylene imine.						
	(c) As determined by infrared and NMR Spectroscopy.						

10

EXAMPLE XSynthesis of Polyolefins with High Surface Energy:

Low or medium density polyolefins were combined with selected amphiphiles, as shown in Table V, as melts or by solvent blending. The means of compounding was not
 15 important so long as intimate mixing was accomplished. After compounding, the polymeric product was extruded as a film or was extruded as a film directly onto glass. The surface energy of the film was measured by determination of the contact angle of water. Table V details polymeric
 20 compositions produced and the contact angles determined.

TABLE V

WATER^a CONTACT ANGLES OF POLYOLEFIN COMPOSITIONS

<u>Amphiphile</u>		<u>Polyolefin^b</u>	<u>Water Contact Angle^c</u>	
			<u>2%^d</u>	<u>5%^d</u>
25	None	PS	77	--
	O	PS	70	70

(a) Distilled water with 0.01% by weight aniline blue added for contrast.

(b) PS = polystyrene.

30 (c) Decreasing contact angle equals increasing surface energy.

(d) Amphiphile, by weight, added to polyolefin.

EXAMPLE XISynthesis of Amphiphilic Polyesters:

To prevent redistribution and transesterification during esterification, tall oil rosin was first converted to the rosin acid chloride. The acid chloride was reacted with a linear polyester diol, as shown in Table VI, in toluene at 90°C, with pyridine as an HCl scavenger. The product was decanted from over precipitated pyridinium hydrochloride, and the solvent removed by distillation. The product had the characteristics indicated in Table VI.

<u>TABLE VI</u>						
<u>SYNTHESIS OF AMPHIPHILE P</u>						
Carboxylic Acid	Polyester Diol		Amphiphile		Gardner	
Type ^a Wt(g)	Type ^b	Wt(g)	Mol. Wt.	# Acid No. ^c	Color	Yield
TORA 50	PCL	44	630-912	P 25.6	>18	86%

(a) TORA = Tall Oil Rosin Acid;

(b) PCL = polycaprolactone;

(c) mg KOH/g amphiphile

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EXAMPLE XIISynthesis of Polyolefins With High Surface Energy

Low or medium density polyolefins were combined with selected amphiphiles, as shown in Table VII, as melts, by mixing in an extruder or by solvent blending. The means of compounding was not important so long as intimate mixing was accomplished. After compounding, the polymeric product was extruded as a film or was extruded as a film directly onto glass. The surface energy of the film was measured by determination of the contact angle of water. Table VII details polymeric compositions produced and contact angles determined.

TABLE VIIWATER^a CONTACT ANGLES OF POLYOLEFIN COMPOSITIONS

15	<u>Amphiphile</u>	<u>Polyolefin^b</u>	<u>Water Contact Angle^c</u>	
			<u>1%^d</u>	<u>2%^d</u>
	None	LDPE	91	--
	None	PP	82	--
	P	PP	70	65
20	P	LDPE	78	75

(a) Distilled water with 0.01% by weight aniline blue added for contrast.

(b) LDPE = low density polyethylene; PP = polypropylene

25 (c) Decreasing contact angle equals increasing surface.

(d) Amphiphile, by weight, added to polyolefin.

EXAMPLE XIIIPreparation of Amphiphile Q:

30 Amphiphile Q was prepared by the esterification of tall oil rosin acid (Acinol R Type S Tall Oil Rosin, Arizona Chemical Company) with polyethylene glycol (Carbowax type, Union Carbide, molecular weight of 400). Slightly over two equivalent weights of the polyethylene glycol were reacted with the tall oil rosins, in the presence of a phosphoric acid catalyst, at 260°C for 29 hours. The reaction was carried out under a nitrogen blanket with stirring and an

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exit condenser to condense removed water. The resulting amphiphile Q had an acid number of 11 mg KOH/g of product and a Gardner color of 7. The amphiphile was a viscous liquid produced in 94% yield.

5

EXAMPLE XIVPreparation of Film:

Amphiphile Q of Example XIII was combined with low density polyethylene (LDPE) in an extruder, giving a film with 3% by weight of amphiphile. In general, the means of compounding the film was not important so long as intimate mixing was accomplished. The film was extruded onto a paper substrate. A water-dispersed acrylic latex adhesive formulation was roll coated onto the exposed LDPE surface, air dried for 20 minutes at room temperature and then fused by heating for 3 minutes at 100°C.

15

EXAMPLE XV

The adhesive coated film of Example XIV was cut into 1 inch by 5 inch strips and adhered to stainless steel plates. Adhesion was then tested as 180° peel strength with a separation rate of 12 inches/minute. At short dwell times (dwell time is the contact time of adhesive to steel between application and testing), between 30 minutes and 1 hour, the composites gave good peel strength (see Table VIII) with failure occurring at the adhesive/steel interface. With longer dwell times, greater than 3 hours, the composite failed within the paper substrate. In all cases, there was no failure at the LDPE/acrylic interface.

20

25

TABLE VIII

<u>Adhesive Dwell Time (hr)</u>		<u>180° Peel Strength (oz/in)^a</u>
30 Avery Chemical ^b	0.5	60.5
ROBOND ^c	1.0	96.9
ROBOND	>3	(d)

(a) Film thicknesses for both coatings were 1 mill (0.001 inch).

35 (b) A proprietary acrylic supplied by Avery Chemical, tackified with 30% by weight AQUATAC 6085 (Arizona Chemical).

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- (c) ROBOND PS-95, formerly Rohm and Haas E2395 supplied by Rohm and Haas.
- (d) Failure occurred within paper substrate; no peel strength recorded.

5 From the foregoing, it may be seen that the addition of the amphiphile to a low density polyolefin greatly increases the surface energy of the low density polyolefin. Since printing and adhesion are most efficient at water contact angles of less than 70°, the addition of the amphiphile greatly increases the usability of the polymeric material. The example also illustrates that the surface energy of the polymeric material can be raised to the desired level by the addition of the appropriate amount of amphiphile to the polymeric material.

10 This improvement in the surface energy of the polymeric material extends beyond low density polyethylene to a wide range of low and medium density polyolefins, including polypropylene, alpha-olefin modified polypropylene and polyethylene, polystyrene and TPX. In addition, the surface energy is improved for a period of time greater than 8 months as compared to prior treatments which were effective only for a period of four weeks or less. Therefore, the present invention provides for a means of increasing the surface energy of low and medium density organic polymeric materials for relatively long periods of time.

15 It is also shown that an effective adhesive tape is produced from the high surface energy polyolefins of the present invention. When subjected to tests for peel strength, the bond fails in the substrate and not at the polymer surface.

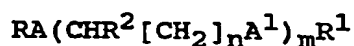
20 Various of the features of the invention which are believed to be new are set forth in the appended claims.

THE CLAIMS:

1. A low or medium density polyolefinic composition comprised of:

from about 99.5% to about 90.0% by weight of a low or medium density, low surface energy polyolefin; and

5 from about 0.5% to about 10.0% by weight of an amphiphile having the formula:



where R and R¹ are selected from the group consisting of the alkyl, aryl, alkylaryl, acyl and arylacyl derivatives of an aliphatic or aliphatic/aromatic mono-acid with a molecular weight of from about 150 to about 500 daltons, A and A¹ are selected from the group consisting of O, S, -NR³- or carboxyl groups and R³ is selected from the group consisting of H, CH₃ and C₂H₅, R² is selected from the group consisting of H, CH₃ and C₂H₅, n is from 0 to 3 and m is from 2 to 20.

2. The composition of Claim 1 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are oxygen.

3. The composition of Claim 1 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are selected from the group consisting of oxygen and sulfur.

4. The composition of Claim 1 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are -NH-.

5. The composition of Claim 1 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are carboxyls.

6. The composition of Claim 1, 2, 3, 4 or 5 wherein said polyolefin is selected from the group consisting of polyethylene, polypropylene, alpha-olefin modified polypropylene, polystyrene and poly(4-methylpentene-1).

7. The composition of Claim 1, 2, 3, 4 or 5 wherein m is from 4 to 12.

8. The composition of Claim 1, 2, 3, 4 or 5 wherein m is 9.

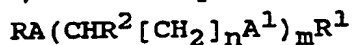
9. The composition of Claim 1, 2, 3, 4 or 5 comprised of:

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between about 99% and about 95% of said polyolefin; and

5 between about 1% and about 5% of said amphiphile.

10. A composition for increasing the surface energy of a low or medium density, low surface energy organic polymeric material, said composition having the formula:



5 where R and R¹ are selected from the group consisting of the alkyl, aryl, alkylaryl, acyl and arylacyl derivatives of an aliphatic or aliphatic/aromatic mono-acid with a molecular weight of from about 150 to about 500 daltons. A and A¹ are selected from the group consisting of O, S, -NR³- and carbonyl and R³ is selected from the group consisting of H, CH₃
10 and C₂H₅, R² is selected from the group consisting of H, CH₃ and C₂H₅, n is from 0 to 3 and m is from 2 to 20, whereby said composition is blended with the organic polymeric material to form a polymeric material with an increased
15 surface energy.

11. The composition of Claim 10 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are oxygen.

12. The composition of Claim 10 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are selected from the group consisting of oxygen and sulfur.

13. The composition of Claim 10 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are -NH-.

14. The composition of Claim 10 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are carboxyls.

15. The composition of Claim 10, 11, 12, 13 or 14 wherein m is from 4 to 12.

16. The composition of Claim 10, 11, 12, 13 or 14 wherein m is 9.

17. An adhesive tape comprising:

A low or medium density polyolefinic composition comprised of:

5 from about 99.5% to about 90.0% by weight of a low or medium density, low surface energy polyolefin; and

from about 0.5% to about 10.0% by weight of an amphiphile having the formula:



10 where R and R¹ are selected from the group consisting of the alkyl, aryl, alkylaryl, acyl and arylacyl derivatives of an aliphatic or aliphatic/aromatic mono-acid with a molecular weight of from about 200 to about 500 daltons, A and A¹ are selected from the group consisting of 15 O, -NR³-, carboxyl and S, R² and R³ are selected from the group consisting of H, CH₃ and C₂H₅, n is from 0 to 3 and m is from 2 to 20; and a water dispersed-adhesive.

18. The adhesive tape of Claim 17 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are oxygen.

19. The adhesive tape of Claim 17 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are selected from the group consisting of oxygen and sulfur.

20. The adhesive tape of Claim 17 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are NH.

21. The adhesive tape of Claim 17 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are carboxyls.

22. The adhesive tape of Claim 17, 18, 19, 20 or 21 wherein said polyolefin is selected from the group consisting of polyethylene, polypropylene, alpha-olefin modified polypropylene, polystyrene and poly(4-methylpentene- 5 1).

23. The adhesive tape of Claim 17, 18, 19, 20 or 21 wherein m is from 4 to 12.

24. The adhesive tape of Claim 17, 18, 19, 20 or 21 comprised of:

between about 99% and about 95% of said polyolefin; and

5 between about 1% and about 5% of said amphiphile.

25. The adhesive tape of Claim 17, 18, 19, 20 or 21 wherein the adhesive is an acrylic adhesive.

26. A method for increasing the surface energy of a low or medium density, low surface energy organic polymeric material comprising blending from about 99.5% to about 90.0% by weight of said polymeric material with from about 0.5% to about 10.0% by weight of an amphiphile having the formula



- where R and R¹ are selected from the group consisting of the alkyl, aryl, alkylaryl, acyl and arylacyl derivatives of an aliphatic or aliphatic/aromatic mono-acid with a molecular weight of from about 150 to about 500 daltons, R² is selected from the group consisting of H, CH₃ and C₂H₅, A and A¹ are selected from the group consisting of O, S, -NR³- or carboxyl groups, R³ is selected from the group consisting of H, CH₃ and C₂H₅, m is from 2 to 20 and n is from 0 to 3.

27. The method of Claim 26 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are oxygen.

28. The method of Claim 26 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are selected from the group consisting of oxygen and sulfur.

29. The method of Claim 26 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are - NH -.

30. The method of Claim 26 wherein R and R¹ are identical, R² is hydrogen and A and A¹ are carboxyls.

31. The method of Claims 26, 27, 28, 29 or 30 wherein said polymeric material is selected from the group consisting of polyethylene, polypropylene, alpha-olefin modified polypropylene, polystyrene and poly(4-methylpene-1).

32. The method of Claims 26, 27, 28, 29 or 30 wherein m is from 4 to 12.

33. The method of Claims 26, 27, 28, 29 or 30 wherein m is 9.

34. The method of Claims 26, 27, 28, 29 or 30 wherein there is between about 99% and about 95% of said organic polymeric material and there is between about 1% and

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about 5% of said amphiphile.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US90/05597

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC (5): B32B 7/12; C08K 5/09		
U.S. CL. 428/343; 524/306		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
U.S.	524/306, 307, 308, 378, 368; 428/343, 355	
Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ^a	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
Y	US, A, 4,506,037 (SUZUKI ET AL) 19 MARCH 1985; See column 2, lines 19-40 and column 3, lines 1-12.	1-16, 26-34
Y	US, A, 4,792,582 (HOEFER ET AL) 20 DECEMBER 1988; See the entire document.	1-16, 26-34
Y	US, A, 4,762,747 (LIU ET AL) 09 AUGUST 1988; See the entire document.	17-25
Y	US, A, 4,781,957 (BROWN ET AL) 01 NOVEMBER 1988; See the entire document.	17-25
<p>* Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
02 JANUARY 1991		04 FEB 1991
International Searching Authority		Signature of Authorized Officer
ISA/US		Mark Sweet